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Durability of recycled aggregate concrete

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Abstract

Lots of research has already been done on the mechanical properties of recycled aggregate concrete. This led to some changes in the standard for various applications. These authorized application remain quite low risk (Indoor, no frost, …). The durability of recycled aggregate concrete in aggressive environments is one of the more unknown facts. This gives rise to a certain reluctance. While various research data can be found in literature, it is very hard to compare these data due to a variation of the materials used. One of the causes of this variation is the origin of the parent concrete and so the quality of the cement stone. The difference in water absorption of recycled concrete aggregates and the amount of attached mortar are good indicators to measure this quality.

This presentation provides an overview of the various degradation mechanisms in an aqueous environment and the various test methods to measure this degradation. It also provides some links between the quality of recycled concrete aggregates and the different transport mechanisms in recycled aggregate concrete.

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Research strategy

Recycled Concrete Aggregates

- Amount attached mortar
- Water Absorption
- Density

Water Management Concrete

- Water absorption submersion
- Water absorption capillarity
- Evaporation

Resistance Aggressive Environment

- Frost/thaw
- Chlorides
- Acids

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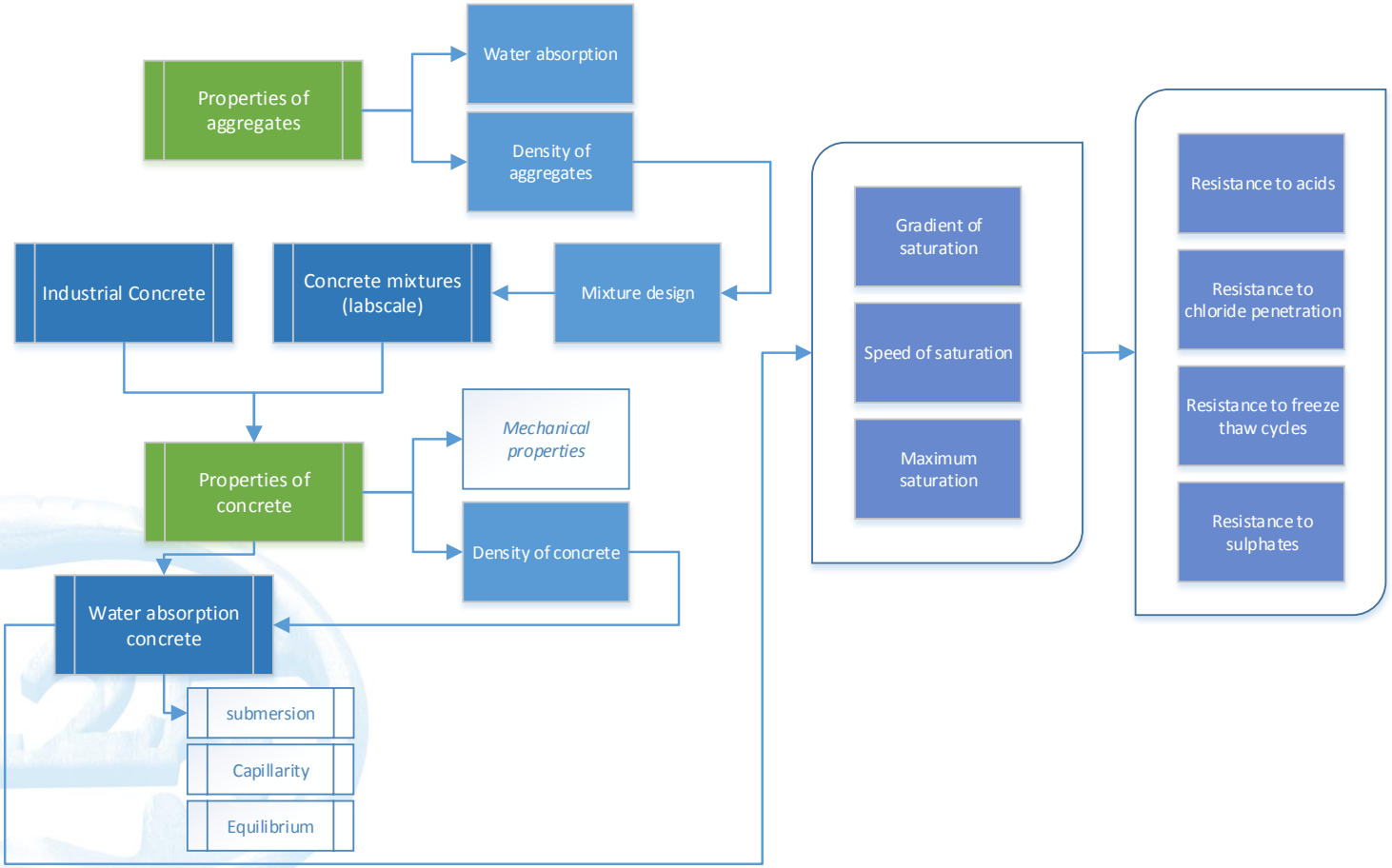
Research Program



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Difference between recycled aggregates and natural aggregates

Recycled aggregates:
- Old aggregates
- Old aggregates + attached mortar
- Old mortar

- Possible Contamination
  - chemicals, red brick, organic material, earth, …

- Increase porosity
- Increase water absorption
- Decrease density

+ uncertainty impurities, quality, …

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Identification and quantification tests done @ KU Leuven Technologiecampus Oostende

- Acid test

✓ After 24 h at 105 °C, the oven-dried aggregate samples are immersed for 24 h in a hydrochloric acid.

✓ The pH of the hydrochloric acid is measured.

✓ If the pH is neutral, the test is repeated, otherwise the solution is drained from the sample and the aggregates washed with tap water over a 5 mm sieve.

✓ The aggregates are then placed in an oven for 24 h at 105 °C, and their oven-dried mass measured

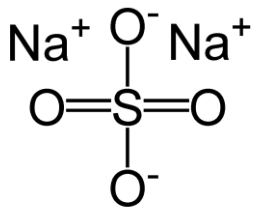
- Sodium Sulphate Solution

✓ After 24 h at 105 °C, the oven-dried aggregate samples are immersed for 24 h in a 26% (by weight) sodium sulphate solution

✓ RCA samples, still in their sodium sulphate solution, are then subjected to five daily cycles of freezing and thawing, i.e. overnight (~ 16 h) at − 17 °C

✓ After the last freezing and thawing cycle, the solution is drained from the sample and the aggregates washed with tap water over a 5 mm sieve.

✓ The aggregates are then placed in an oven for 24 h at 105 °C, and their oven-dried mass measured.



Quantification of the residual mortar content in recycled concrete aggregates by image analysis. A. Abbas et al.

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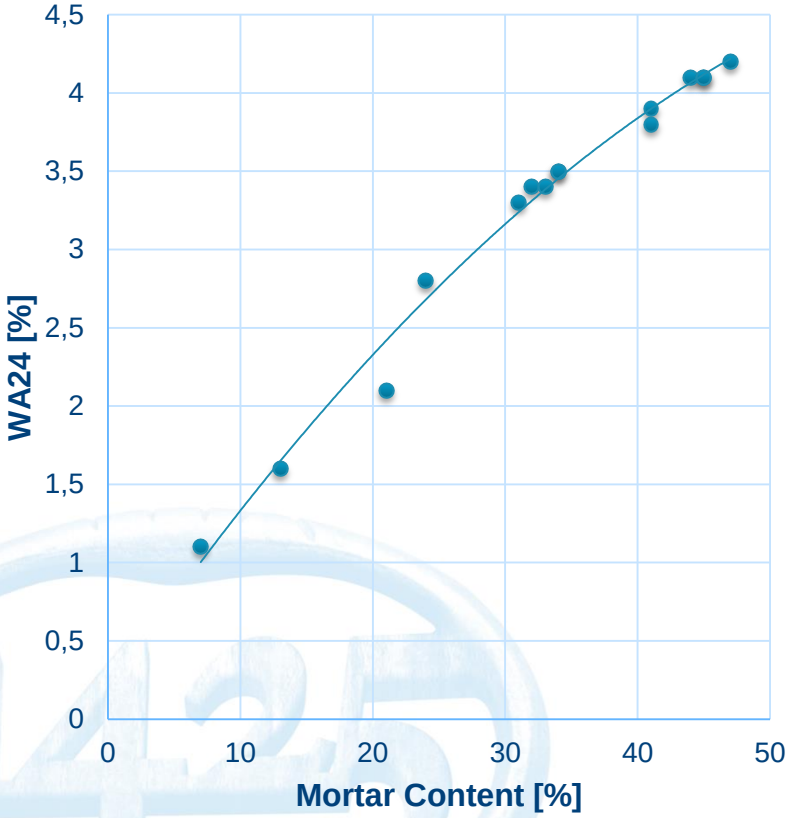
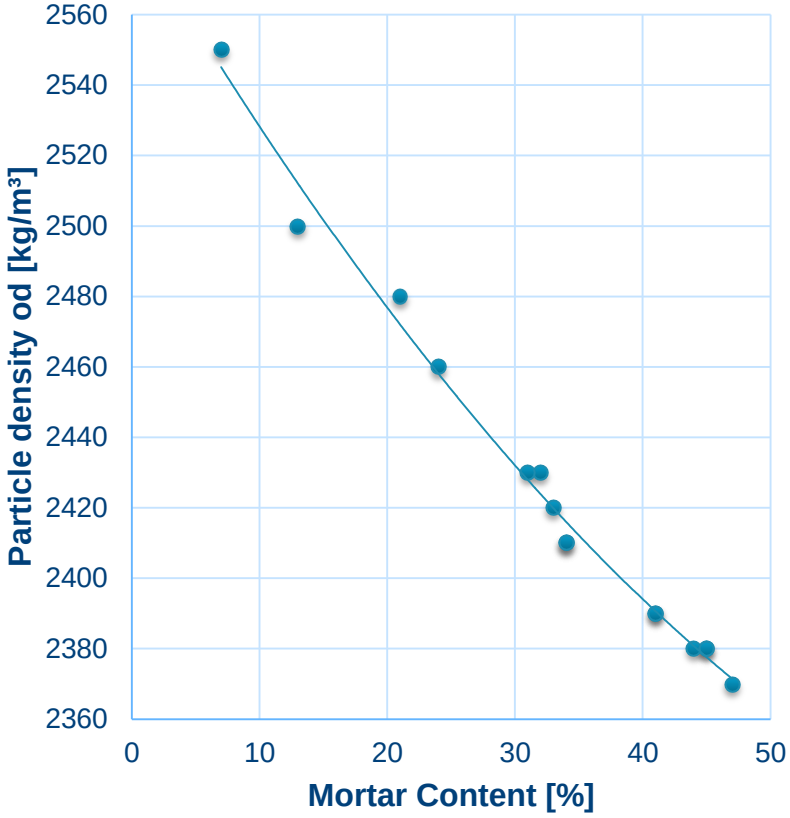
Relationship mortar, water absorption and particle density





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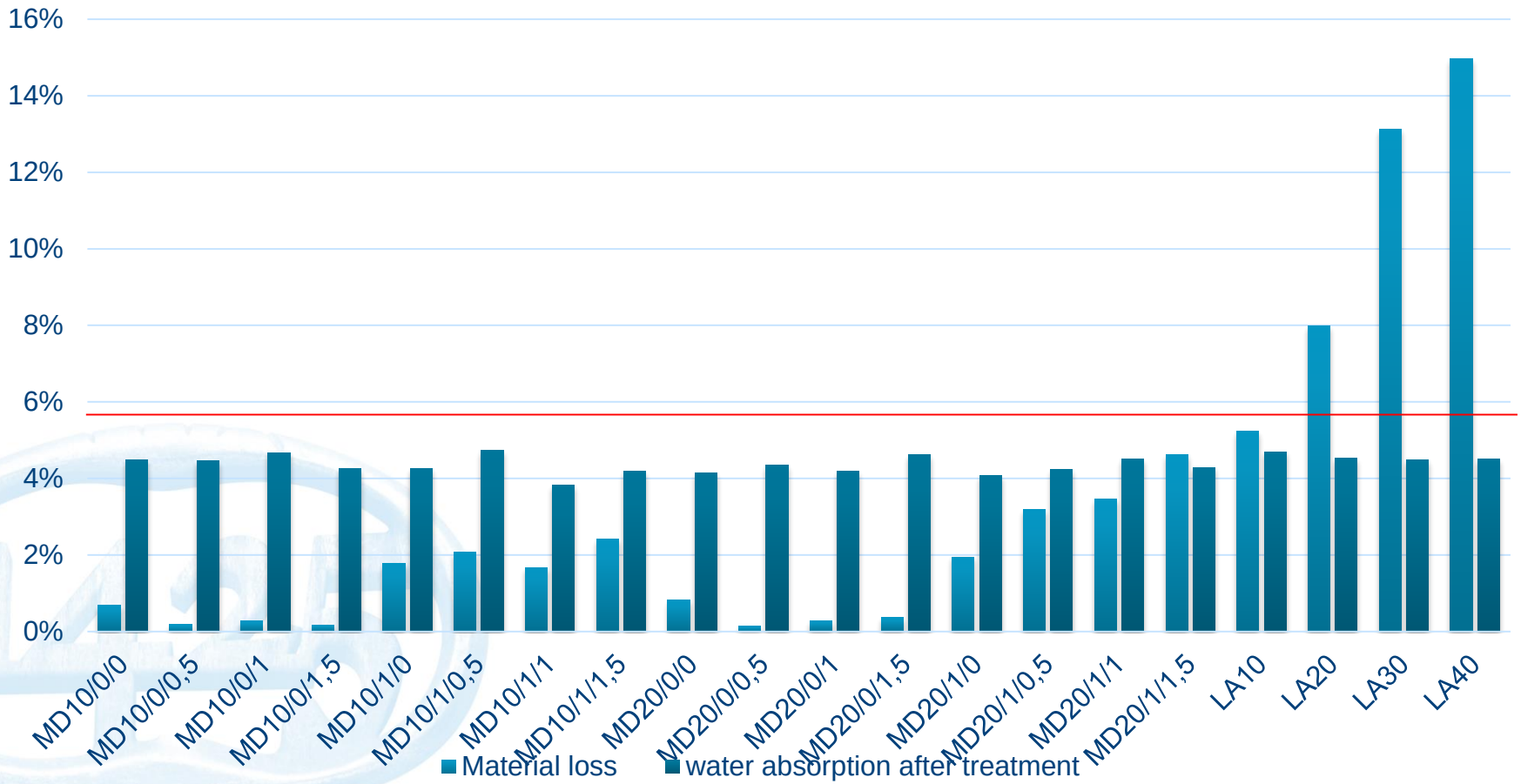
Industrial processes of mortar removal

1. Los Angeles drum
2. Micro-Deval drum
3. concrete-mixer
4. ultrasonic bath
5. heating

Model Water Absorption Recycled Concrete Aggregates



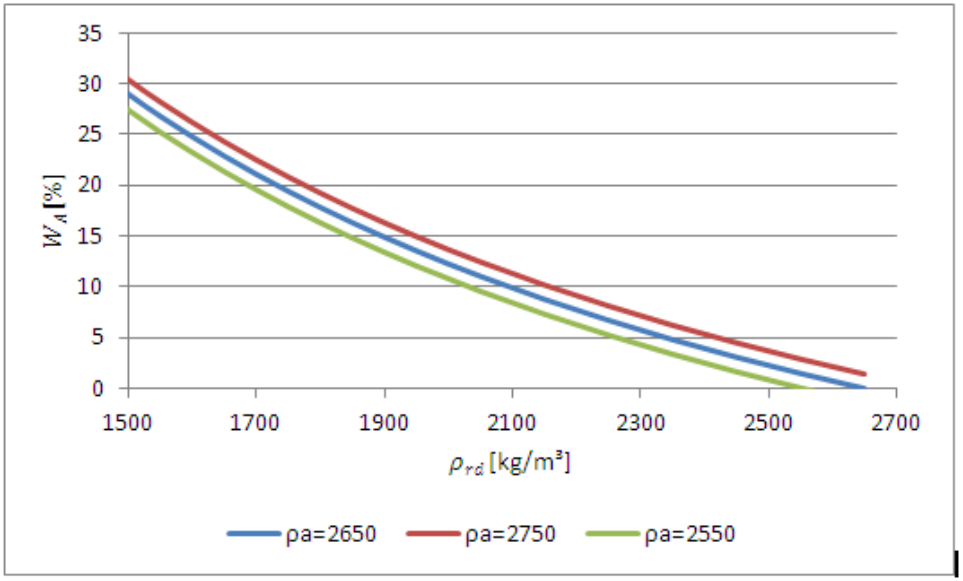
Relationship water absorption density

$$W_A = \frac{m_W}{m_d} = \frac{V_P \rho_w}{\rho_{rd}}$$

$$\rho_a = \frac{\rho_{rd}}{1 - V_P} \Leftrightarrow V_P = 1 - \frac{\rho_{rd}}{\rho_a}$$

$$W_A = \frac{(1 - \frac{\rho_{rd}}{\rho_a})\rho_w}{m_d} = \frac{\rho_w - \frac{\rho_{rd}\rho_w}{\rho_a}}{\rho_{rd}} = \frac{\rho_w}{\rho_{rd}} - \frac{\rho_w}{\rho_a}$$

$$W_A = \frac{1000}{\rho_{rd}} - \frac{1000}{\rho_a}$$



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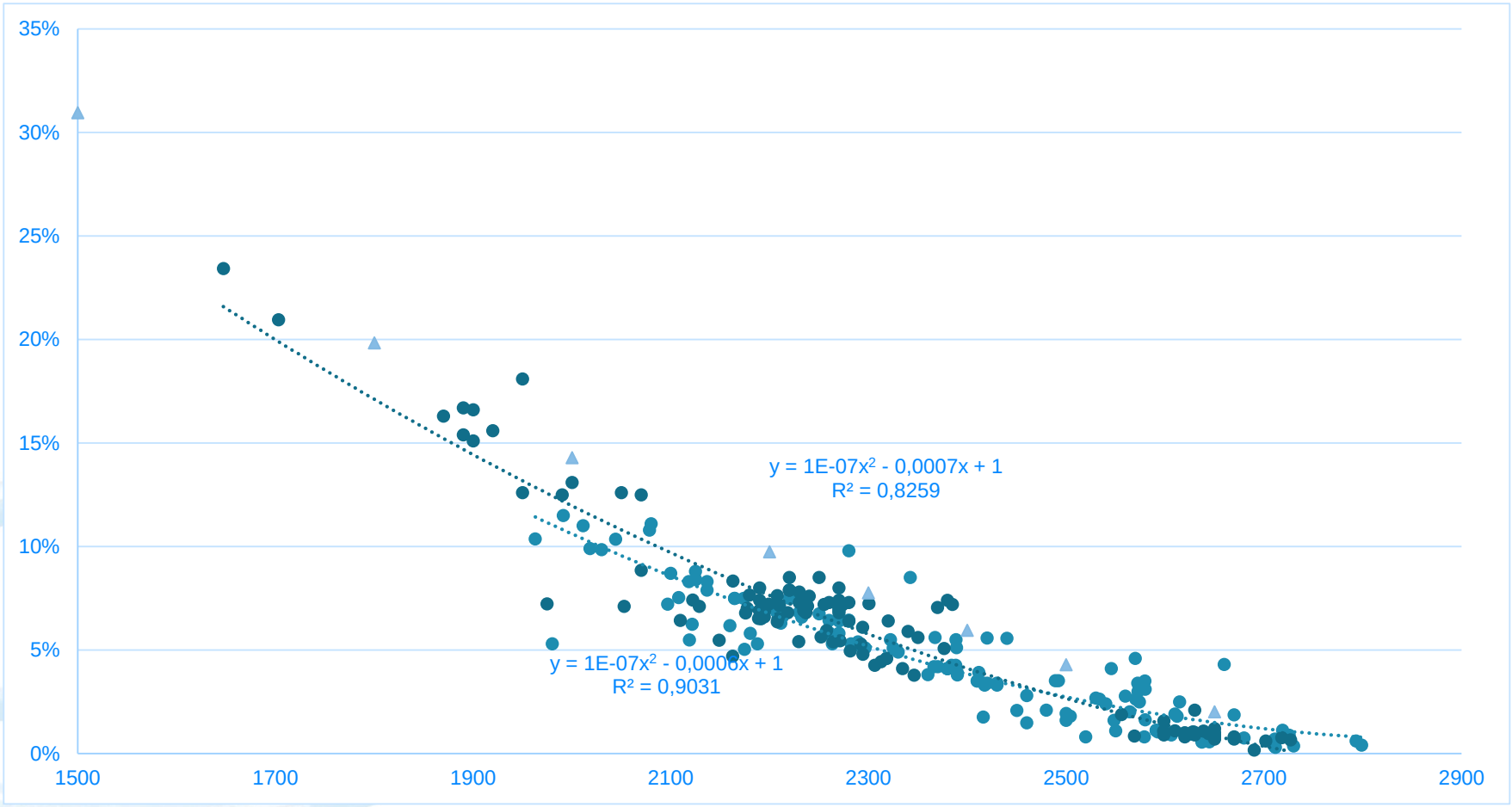
Relationship water absorption density – literature & experiments



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Industrial processes presoaking Recycled Concrete Aggregates

- Industrial methods
  - Presoaking in a water bath
  - Water spraying during transportation
  - Climatized conditions
  - Presoaking during mixing process

- Variables:
  - Time
  - Investment cost
  - Moisture rate after treatment

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Steps PHD

1. Influence of the variability of water absorption of coarse recycled concrete aggregates on the quality of recycled concrete;
2. Model for calculating water absorption rate of coarse recycled concrete aggregates;
3. Industrial methods of prewetting coarse recycled concrete aggregates in recycled concrete;
4. Laboratory methods for measuring the amount of mortar attached to coarse recycled concrete aggregates;
5. Industrial methods of mortar reduction in coarse recycled concrete aggregates;
6. Influence of the quality of coarse recycled concrete aggregates on the water absorption of recycled concrete;
7. Model for calculating water absorption rate of recycled concrete;
8. Model for calculating evaporation rate of water absorbed by of recycled concrete;
9. Resistance of recycled concrete against chloride penetration;
10. Alternative methods to predict the resistance of recycled concrete against chloride penetration;
11. Resistance of recycled concrete against acid;
12. Resistance of recycled concrete against frost-thaw cycles;
13. Life cycle assessment of recycled concrete in an aggressive environment.